What is claimed is:

1. A radio-wave arrival-direction estimating apparatus comprising:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in said array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a noise spatial eigenmatrix calculation unit for calculating a noise spatial eigenmatrix by eigenvalue factorization of the correlation matrix, one of a row and a column of the noise spatial eigenmatrix being an eigenvector belonging to a noise eigen-space;

a triangular matrix calculation unit for factorizing a matrix including a product of the noise spatial eigenmatrix and a conjugated and transposed matrix of the noise spatial eigenmatrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value from said arrival-angle evaluation unit.

2. A radio-wave arrival-direction estimating apparatus according to claim

1 further comprising a unitary transforming unit for unitary-transforming the correlation matrix, wherein

the plurality of antenna elements are arranged linearly at a constant interval, and

said noise spatial eigenmatrix calculation unit applies the eigenvalue factorization to the unitary-transformed correlation matrix.

3. A radio-wave arrival-direction estimating apparatus according to claim 1, wherein said triangular matrix calculation unit factorizes input matrix R to product U^HU of upper triangular matrix U by cholesky factorization.

4. A radio-wave arrival-direction estimating apparatus according to claim 1, wherein said triangular matrix calculation unit factorizes input matrix R to product LL^H of lower triangular matrix L by cholesky factorization.

5. A radio-wave arrival-direction estimating apparatus according to claim 1, wherein said triangular matrix calculation unit factorizes an input matrix to product U^HDU of upper triangular matrix U and diagonal matrix D by modified cholesky factorization.

6. A radio-wave arrival-direction estimating apparatus according to claim 1, wherein said triangular matrix calculation unit factorizes an input matrix to product LDL^H of lower triangular matrix L and diagonal matrix D by modified cholesky factorization.

7. A radio-wave arrival-direction estimating apparatus according to claim 1, wherein said correlation matrix calculation unit calculates a correlation matrix,

applies a spatial smoothing technique to the correlation matrix, and outputs a resultant matrix.

8. A radio-wave arrival-direction estimating apparatus according to claim 1, wherein

said array antenna includes a plurality of antenna elements arranged linearly at a constant interval, and

said arrival-angle evaluation unit comprises

a positive-region evaluation unit for calculating an evaluation value of an arrival-angle evaluation function for positive angle θ with reference to a bore-sight direction of said array antenna, and

a negative-region evaluation unit for converting the evaluation value by the positive-region evaluation unit to an arrival-angle evaluation value for negative angle (-θ).

9. A radio-wave arrival-direction estimating apparatus according to claim 1, wherein

said array antenna has a linear array shape, and

said arrival-angle evaluation unit sets an angle interval in an end fire direction of said array antenna to be larger than an angle interval in a bore-sight direction, and calculates an evaluation value of an arrival-angle evaluation function.

10. A radio-wave arrival-direction estimating apparatus according to claim 1, further comprising:

a high-accuracy arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function at an angle interval

smaller than an angle interval calculated by said arrival-angle evaluation unit, in a predetermined angle range around the arrival angle supplied from said arrival-angle determination unit; and

a high-accuracy arrival-angle determination unit for highly accurately determining an arrival angle based on the evaluation value by said high-accuracy arrival-angle evaluation unit.

11. A radio-wave arrival-direction estimating apparatus comprising:

an array antenna including a plurality of antenna elements;

an intermediate-frequency receiving unit for performing frequency conversion and phase detection of a RF signal received by each of the antenna elements, and outputting an intermediate frequency signal;

an intermediate-frequency A/D converter for converting the intermediate frequency signal to an intermediate-frequency digital signal;

a digital orthogonal wave detector for orthogonally demodulating the intermediate-frequency digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a noise spatial eigenmatrix calculation unit for calculating a noise spatial eigenmatrix by eigenvalue factorization of the correlation matrix, one of a row and a column of the noise spatial eigenmatrix being an eigenvector belonging to a noise eigen-space;

a triangular matrix calculation unit for factorizing a matrix including a product of the noise spatial eigenmatrix and a conjugated and transposed matrix of the noise spatial eigenmatrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value from said arrival-angle evaluation unit.

12. A radio-wave arrival-direction estimating apparatus comprising:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in said array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

an inverse matrix calculation unit for calculating an inverse matrix of the correlation matrix;

a triangular matrix calculation unit for factorizing the inverse matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value from said arrival-angle evaluation unit.

13. A radio-wave arrival-direction estimating apparatus according to claim 12 further comprising a unitary transforming unit for unitary-transforming the correlation matrix, wherein

the plurality of antenna elements are arranged linearly at a constant interval, and

said inverse matrix calculation unit calculates an inverse matrix of the unitary-transformed correlation matrix.

14. A radio-wave arrival-direction estimating apparatus according to claim 12, wherein said triangular matrix calculation unit factorizes input matrix R to product $U^{H}U$ of upper triangular matrix U by cholesky factorization.

15. A radio-wave arrival-direction estimating apparatus according to claim 12, wherein said triangular matrix calculation unit factorizes input matrix R to product LL^{H} of lower triangular matrix L by cholesky factorization.

16. A radio-wave arrival-direction estimating apparatus according to claim 12, wherein said triangular matrix calculation unit factorizes an input matrix to product $U^{H}DU$ of upper triangular matrix U and diagonal matrix D by modified cholesky factorization.

17. A radio-wave arrival-direction estimating apparatus according to claim 12, wherein said triangular matrix calculation unit factorizes an input matrix to product LDL^{H} of lower triangular matrix L and diagonal matrix D by modified cholesky factorization.

18. A radio-wave arrival-direction estimating apparatus according to claim 12, wherein said correlation matrix calculation unit calculates a correlation matrix, applies a spatial smoothing technique to the correlation matrix, and outputs a resultant matrix.

19. A radio-wave arrival-direction estimating apparatus according to claim 12, wherein

said array antenna includes a plurality of antenna elements arranged linearly at a constant interval, and

said arrival-angle evaluation unit comprises

a positive-region evaluation unit for calculating an evaluation value of an arrival-angle evaluation function for positive angle θ with reference to a bore-sight direction of said array antenna, and

a negative-region evaluation unit for converting the evaluation value by the positive-region evaluation unit to an arrival-angle evaluation value for negative angle $(-\theta)$.

20. A radio-wave arrival-direction estimating apparatus according to claim 12, wherein

said array antenna has a linear array shape, and

said arrival-angle evaluation unit sets an angle interval in an end fire direction of said array antenna to be larger than an angle interval in a bore-sight direction, and calculates an evaluation value of an arrival-angle evaluation function.

21. A radio-wave arrival-direction estimating apparatus according to claim 12, further comprising:

a high-accuracy arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function at an angle interval smaller than an angle interval calculated by said arrival-angle evaluation unit, in a predetermined angle range around the arrival angle supplied from said arrival-angle determination unit; and

a high-accuracy arrival-angle determination unit for highly accurately determining an arrival angle based on the evaluation value by said high-accuracy arrival-angle evaluation unit.

22. A radio-wave arrival-direction estimating apparatus comprising:

an array antenna including a plurality of antenna elements;

an intermediate-frequency receiving unit for performing frequency conversion and phase detection of a RF signal received by each of the antenna elements, and outputting an intermediate frequency signal;

an intermediate-frequency A/D converter for converting the intermediate frequency signal to an intermediate-frequency digital signal;

a digital orthogonal wave detector for orthogonally demodulating the intermediate-frequency digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

an inverse matrix calculation unit for calculating an inverse matrix of the correlation matrix;

a triangular matrix calculation unit for factorizing the inverse matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle

evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by said arrival-angle evaluation unit.

23. A radio-wave arrival-direction estimating apparatus comprising:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in said array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an inverse matrix calculation unit for calculating an inverse matrix of the one of the upper triangular matrix and the lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the inverse matrix of the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by said arrival-angle evaluation unit.

24. A radio-wave arrival-direction estimating apparatus according to

claim 23 further comprising a unitary transforming unit for unitary-transforming the correlation matrix, wherein

the plurality of antenna elements are arranged linearly at a constant interval, and

said triangular matrix calculation unit factorizes the unitary-transformed correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix.

25. A radio-wave arrival-direction estimating apparatus according to claim 23, wherein said triangular matrix calculation unit factorizes input matrix R to product U^HU of upper triangular matrix U by cholesky factorization.

26. A radio-wave arrival-direction estimating apparatus according to claim 23, wherein said triangular matrix calculation unit factorizes input matrix R to product LL^H of lower triangular matrix L by cholesky factorization.

27. A radio-wave arrival-direction estimating apparatus according to claim 23, wherein said triangular matrix calculation unit factorizes an input matrix to product U^HDU of upper triangular matrix U and diagonal matrix D by modified cholesky factorization.

28. A radio-wave arrival-direction estimating apparatus according to claim 23, wherein said triangular matrix calculation unit factorizes an input matrix to product LDL^H of lower triangular matrix L and diagonal matrix D by modified cholesky factorization.

29. A radio-wave arrival-direction estimating apparatus according to

claim 23, wherein said correlation matrix calculation unit calculates a correlation matrix, applies a spatial smoothing technique to the correlation matrix, and outputs a resultant matrix.

30. A radio-wave arrival-direction estimating apparatus according to claim 23, wherein

said array antenna includes a plurality of antenna elements arranged linearly at a constant interval, and

said arrival-angle evaluation unit comprises

a positive-region evaluation unit for calculating an evaluation value of an arrival-angle evaluation function for positive angle θ with reference to a bore-sight direction of said array antenna, and

a negative-region evaluation unit for converting the evaluation value by the positive-region evaluation unit to an arrival-angle evaluation value for negative angle $(-\theta)$.

31. A radio-wave arrival-direction estimating apparatus according to claim 23, wherein

said array antenna has a linear array shape, and

said arrival-angle evaluation unit sets an angle interval in an end fire direction of said array antenna to be larger than an angle interval in a bore-sight direction, and calculates an evaluation value of an arrival-angle evaluation function.

32. A radio-wave arrival-direction estimating apparatus according to claim 23, further comprising:

a high-accuracy arrival-angle evaluation unit for calculating an

evaluation value of an arrival-angle evaluation function at an angle interval smaller than an angle interval calculated by said arrival-angle evaluation unit, in a predetermined angle range around the arrival angle supplied from said arrival-angle determination unit; and

a high-accuracy arrival-angle determination unit for highly accurately determining an arrival angle based on the evaluation value by said high-accuracy arrival-angle evaluation unit.

33. A radio-wave arrival-direction estimating apparatus comprising:

an array antenna including a plurality of antenna elements;

an intermediate-frequency receiving unit for performing frequency conversion and phase detection of a RF signal received by each of the antenna elements, and outputting an intermediate frequency signal;

an intermediate-frequency A/D converter for converting the intermediate frequency signal to an intermediate-frequency digital signal;

a digital orthogonal wave detector for orthogonally demodulating the intermediate-frequency digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an inverse matrix calculation unit for calculating an inverse matrix of the one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the inverse matrix of the one of the

upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by said arrival-angle evaluation unit.

34. A radio-wave arrival-direction estimating apparatus comprising:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in said array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by said arrival-angle evaluation unit.

35. A radio-wave arrival-direction estimating apparatus according to claim 34 further comprising a unitary transforming unit for unitary-transforming the correlation matrix, wherein

the plurality of antenna elements are arranged linearly at a constant

interval, and

said triangular matrix calculation unit factorizes the unitary-transformed correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix.

36. A radio-wave arrival-direction estimating apparatus according to claim 34, wherein said triangular matrix calculation unit factorizes input matrix R to product U^HU of upper triangular matrix U by cholesky factorization.

37. A radio-wave arrival-direction estimating apparatus according to claim 34, wherein said triangular matrix calculation unit factorizes input matrix R to product LL^H of lower triangular matrix L by cholesky factorization.

38. A radio-wave arrival-direction estimating apparatus according to claim 34, wherein said triangular matrix calculation unit factorizes an input matrix to product U^HDU of upper triangular matrix U and diagonal matrix D by modified cholesky factorization.

39. A radio-wave arrival-direction estimating apparatus according to claim 34, wherein said triangular matrix calculation unit factorizes an input matrix to product LDL^H of lower triangular matrix L and diagonal matrix D by modified cholesky factorization.

40. A radio-wave arrival-direction estimating apparatus according to claim 34, wherein said correlation matrix calculation unit calculates a correlation matrix, applies a spatial smoothing technique to the correlation matrix, and outputs a resultant matrix.

41. A radio-wave arrival-direction estimating apparatus according to claim 34, wherein

said array antenna includes a plurality of antenna elements arranged linearly at a constant interval, and

said arrival-angle evaluation unit comprises

a positive-region evaluation unit for calculating an evaluation value of an arrival-angle evaluation function for positive angle θ with reference to a bore-sight direction of said array antenna, and

a negative-region evaluation unit for converting the evaluation value by the positive-region evaluation unit to an arrival-angle evaluation value for negative angle $(-\theta)$.

42. A radio-wave arrival-direction estimating apparatus according to claim 34, wherein

said array antenna has a linear array shape, and

said arrival-angle evaluation unit sets an angle interval in an end fire direction of said array antenna to be larger than an angle interval in a bore-sight direction, and calculates an evaluation value of an arrival-angle evaluation function.

43. A radio-wave arrival-direction estimating apparatus according to claim 34, further comprising:

a high-accuracy arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function at an angle interval smaller than an angle interval calculated by said arrival-angle evaluation unit, in a predetermined angle range around the arrival angle supplied from said arrival-

angle determination unit; and

a high-accuracy arrival-angle determination unit for highly accurately determining an arrival angle based on the evaluation value by said high-accuracy arrival-angle evaluation unit.

44. A radio-wave arrival-direction estimating apparatus comprising:

an array antenna including a plurality of antenna elements;

an intermediate-frequency receiving unit for performing frequency conversion and phase detection of a RF signal received by each of the antenna elements, and outputting an intermediate frequency signal;

an intermediate-frequency A/D converter for converting the intermediate frequency signal to an intermediate-frequency digital signal;

a digital orthogonal wave detector for orthogonally demodulating the intermediate-frequency digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by said arrival-angle evaluation unit.

45. A radio-wave arrival-direction estimating apparatus comprising:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in said array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation vector calculation unit for calculating a correlation vector by correlation calculation between a reference antenna element and another antenna element, the reference antenna element corresponding to a selected complex digital signal;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the correlation vector; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by said arrival-angle evaluation unit.

46. A radio-wave arrival-direction estimating apparatus according to claim 45 further comprising a unitary transforming unit for unitary-transforming the correlation vector, wherein

the plurality of antenna elements are arranged linearly at a constant interval, and

said arrival-angle evaluation unit calculates an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the unitary-transformed correlation vector.

47. A radio-wave arrival-direction estimating apparatus according to

claim 45, wherein

said array antenna includes a plurality of antenna elements arranged linearly at a constant interval, and

said arrival-angle evaluation unit comprises

a positive-region evaluation unit for calculating an evaluation value of an arrival-angle evaluation function for positive angle θ with reference to a bore-sight direction of said array antenna, and

a negative-region evaluation unit for converting the evaluation value by the positive-region evaluation unit to an arrival-angle evaluation value for negative angle (-θ).

48. A radio-wave arrival-direction estimating apparatus according to claim 45, wherein

said array antenna has a linear array shape, and

said arrival-angle evaluation unit sets an angle interval in an end fire direction of said array antenna to be larger than an angle interval in a bore-sight direction, and calculates an evaluation value of an arrival-angle evaluation function.

49. A radio-wave arrival-direction estimating apparatus according to claim 45, further comprising:

a high-accuracy arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function at an angle interval smaller than an angle interval calculated by said arrival-angle evaluation unit, in a predetermined angle range around the arrival angle supplied from said arrival-angle determination unit; and

a high-accuracy arrival-angle determination unit for highly accurately

determining an arrival angle based on the evaluation value by said high-accuracy arrival-angle evaluation unit.

50. A radio-wave arrival-direction estimating apparatus comprising:

an array antenna including a plurality of antenna elements;

an intermediate-frequency receiving unit for performing frequency conversion and phase detection of a RF signal received by each of the antenna elements, and outputting an intermediate frequency signal;

an intermediate-frequency A/D converter for converting the intermediate frequency signal to an intermediate-frequency digital signal;

a digital orthogonal wave detector for orthogonally demodulating the intermediate-frequency digital signal;

a correlation vector calculation unit for calculating a correlation vector by correlation calculation between a reference antenna element and another antenna element, the reference antenna element corresponding to a selected complex digital signal;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the correlation vector; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by said arrival-angle evaluation unit.

51. A directivity variable receiver comprising:

a radio-wave arrival-direction estimating apparatus including:

an array antenna having a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the

converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation vector calculation unit for calculating a correlation vector by correlation calculation between a reference antenna element and another antenna element, the reference antenna element corresponding to a selected complex digital signal;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the correlation vector; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit;

a plurality of sector antennas having different main beam directions;

a sector control unit for outputting a sector control signal used for selecting one sector antenna from said plurality of sector antennas, the selected sector antenna having a beam direction in a direction estimated by said radio-wave arrival-direction estimating apparatus;

a sector switch for alternatively coupling the sector antenna based on the sector control signal; and

a receiving unit for demodulating an output signal of said sector switch.

52. A directivity variable receiver according to claim 51, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation vector, and

the arrival-angle evaluation unit calculates an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the unitary-transformed correlation vector.

53. A directivity variable receiver according to claim 51,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a noise spatial eigenmatrix calculation unit for calculating a noise spatial eigenmatrix by eigenvalue factorization of the correlation matrix, one of a row and a column of the noise spatial eigenmatrix being an eigenvector belonging to a noise eigen-space;

a triangular matrix calculation unit for factorizing a matrix including a product of the noise spatial eigenmatrix and a conjugated and transposed matrix of the noise spatial eigenmatrix to a product of one of an upper triangular matrix and a lower triangular matrix; and

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle

evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix.

54. A directivity variable receiver according to claim 53, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the noise spatial eigenmatrix calculation unit applies the eigenvalue factorization to the unitary-transformed correlation matrix.

55. A directivity variable receiver according to claim 51,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

an inverse matrix calculation unit for calculating an inverse matrix of the correlation matrix;

a triangular matrix calculation unit for factorizing the inverse matrix

to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

56. A directivity variable receiver according to claim 55, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the inverse matrix calculation unit calculates an inverse matrix of the unitary-transformed correlation matrix.

57. A directivity variable receiver according to claim 51,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation

matrix by correlation calculation of the complex digital signal between the antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an inverse matrix calculation unit for calculating an inverse matrix of the one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the inverse matrix of the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

58. A directivity variable receiver according to claim 57, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the triangular matrix calculation unit factorizes the unitary-transformed correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix

59. A directivity variable receiver according to claim 51,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

60. A directivity variable receiver according to claim 59, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the triangular matrix calculation unit factorizes the unitary-transformed correlation matrix to a product of one of an upper triangular matrix and a lower

triangular matrix

61. A directivity variable receiver comprising:

a radio-wave arrival-direction estimating apparatus including:

an array antenna having a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation vector calculation unit for calculating a correlation vector by correlation calculation between a reference antenna element and another antenna element, the reference antenna element corresponding to a selected complex digital signal;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the correlation vector; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit;

a directivity control unit for assigning a complex weight to the demodulated signal and combines the signals with each other so as to generate directivity of the array antenna to an arrival direction of the radio-wave arrival-direction estimating apparatus; and

a receiving unit for demodulating an output signal of the directivity control unit.

62. A directivity variable receiver according to claim 61, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation vector, and

the arrival-angle evaluation unit calculates an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the unitary-transformed correlation vector.

63. A directivity variable receiver according to claim 61,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a noise spatial eigenmatrix calculation unit for calculating a noise spatial eigenmatrix by eigenvalue factorization of the correlation matrix, one of a row and a column of the noise spatial eigenmatrix being an eigenvector belonging to a noise eigen-space;

a triangular matrix calculation unit for factorizing a matrix including a

product of the noise spatial eigenmatrix and a conjugated and transposed matrix of the noise spatial eigenmatrix to a product of one of an upper triangular matrix and a lower triangular matrix; and

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix.

64. A directivity variable receiver according to claim 63, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the noise spatial eigenmatrix calculation unit applies the eigenvalue factorization to the unitary-transformed correlation matrix.

65. A directivity variable receiver according to claim 61,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation

matrix by correlation calculation of the complex digital signal between the antenna elements;

an inverse matrix calculation unit for calculating an inverse matrix of the correlation matrix;

a triangular matrix calculation unit for factorizing the inverse matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

66. A directivity variable receiver according to claim 65, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the inverse matrix calculation unit calculates an inverse matrix of the unitary-transformed correlation matrix.

67. A directivity variable receiver according to claim 61,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal

received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an inverse matrix calculation unit for calculating an inverse matrix of the one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the inverse matrix of the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

68. A directivity variable receiver according to claim 67, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the triangular matrix calculation unit factorizes the unitary-transformed correlation matrix to a product of one of an upper triangular matrix and a lower

triangular matrix

69. A directivity variable receiver according to claim 61,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

70. A directivity variable receiver according to claim 69, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the triangular matrix calculation unit factorizes the unitary-transformed correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix

71. A directivity variable transmitter comprising:

a radio-wave arrival-direction estimating apparatus including:

an array antenna having a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation vector calculation unit for calculating a correlation vector by correlation calculation between a reference antenna element and another antenna element, the reference antenna element corresponding to a selected complex digital signal;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the correlation vector; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit;

a plurality of sector antennas having different main beam directions;

a sector control unit for outputting a sector control signal used for selecting one sector antenna from said plurality of sector antennas, the selected

sector antenna having a beam direction in a direction estimated by said radio-wave arrival-direction estimating apparatus;

a sector switch for alternatively coupling the sector antenna based on the sector control signal; and

a transmitting unit for transmitting a modulated signal after frequency conversion from said sector antennas.

72. A directivity variable transmitter according to claim 71, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation vector, and

the arrival-angle evaluation unit calculates an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the unitary-transformed correlation vector.

73. A directivity variable transmitter according to claim 71,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a noise spatial eigenmatrix calculation unit for calculating a noise spatial eigenmatrix by eigenvalue factorization of the correlation matrix, one of a row and a column of the noise spatial eigenmatrix being an eigenvector belonging to a noise eigen-space;

a triangular matrix calculation unit for factorizing a matrix including a product of the noise spatial eigenmatrix and a conjugated and transposed matrix of the noise spatial eigenmatrix to a product of one of an upper triangular matrix and a lower triangular matrix; and

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix.

74. A directivity variable transmitter according to claim 73, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the noise spatial eigenmatrix calculation unit applies the eigenvalue factorization to the unitary-transformed correlation matrix.

75. A directivity variable transmitter according to claim 71,

wherein said radio-wave arrival-direction estimating apparatus

comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

an inverse matrix calculation unit for calculating an inverse matrix of the correlation matrix;

a triangular matrix calculation unit for factorizing the inverse matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

76. A directivity variable transmitter according to claim 75, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the inverse matrix calculation unit calculates an inverse matrix of the unitary-transformed correlation matrix.

77. A directivity variable transmitter according to claim 71,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an inverse matrix calculation unit for calculating an inverse matrix of the one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the inverse matrix of the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

78. A directivity variable transmitter according to claim 77, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the triangular matrix calculation unit factorizes the unitary-transformed correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix

79. A directivity variable transmitter according to claim 71,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-

angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

80. A directivity variable transmitter according to claim 79, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the triangular matrix calculation unit factorizes the unitary-transformed correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix

81. A directivity variable transmitter comprising:

a radio-wave arrival-direction estimating apparatus including:

an array antenna having a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation vector calculation unit for calculating a correlation vector by correlation calculation between a reference antenna element and another antenna element, the reference antenna element corresponding to a selected complex digital signal;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the correlation vector; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit;

a transmitting unit for generating a transmitted signal;

a directivity control unit for assigning a complex weight to the transmitted signal so as to generate antenna directivity to an arrival direction determined by the radio-wave arrival-direction estimating apparatus;

a transmitting unit for converting frequency of an output from said directivity control unit; and

an array antenna for transmitting an output from said transmitting unit.

82. A directivity variable transmitter according to claim 81, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation vector, and

the arrival-angle evaluation unit calculates an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the unitary-transformed correlation vector.

83. A directivity variable transmitter according to claim 81,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a noise spatial eigenmatrix calculation unit for calculating a noise spatial eigenmatrix by eigenvalue factorization of the correlation matrix, one of a row and a column of the noise spatial eigenmatrix being an eigenvector belonging to a noise eigen-space;

a triangular matrix calculation unit for factorizing a matrix including a product of the noise spatial eigenmatrix and a conjugated and transposed matrix of the noise spatial eigenmatrix to a product of one of an upper triangular matrix and a lower triangular matrix; and

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix.

84. A directivity variable transmitter according to claim 83, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation

matrix, and

the noise spatial eigenmatrix calculation unit applies the eigenvalue factorization to the unitary-transformed correlation matrix.

85. A directivity variable transmitter according to claim 81,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

an inverse matrix calculation unit for calculating an inverse matrix of the correlation matrix;

a triangular matrix calculation unit for factorizing the inverse matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

86. A directivity variable transmitter according to claim 85, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the inverse matrix calculation unit calculates an inverse matrix of the unitary-transformed correlation matrix.

87. A directivity variable transmitter according to claim 81,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an inverse matrix calculation unit for calculating an inverse matrix of the one of the upper triangular matrix and the lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of

an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the inverse matrix of the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

88. A directivity variable transmitter according to claim 87, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the triangular matrix calculation unit factorizes the unitary-transformed correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix

89. A directivity variable transmitter according to claim 81,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the

antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

90. A directivity variable transmitter according to claim 89, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the triangular matrix calculation unit factorizes the unitary-transformed correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix

91. A directivity variable transceiver comprising:

a radio-wave arrival-direction estimating apparatus including:

an array antenna having a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation vector calculation unit for calculating a correlation vector by correlation calculation between a reference antenna element and another antenna element, the reference antenna element corresponding to a selected complex digital signal;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the correlation vector; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit;

a plurality of sector antennas having different main beam directions;

a sector control unit for outputting a sector control signal used for selecting one sector antenna from said plurality of sector antennas, the selected sector antenna having a beam direction in a direction estimated by said radio-wave arrival-direction estimating apparatus;

a sector switch for alternatively coupling the sector antenna based on the sector control signal;

a receiving unit for performing demodulation;

a transmitting unit for performing transmission; and

a switch coupled to the sector antenna for feeding an signal supplied from the selected sector antenna into said receiving unit or for outputting a transmitted signal from said transmitting unit through the selected sector antenna.

92. A directivity variable transceiver according to claim 91, wherein

the plurality of antenna elements are arranged linearly at a constant

interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation vector, and

the arrival-angle evaluation unit calculates an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the unitary-transformed correlation vector.

93. A directivity variable transceiver according to claim 91,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a noise spatial eigenmatrix calculation unit for calculating a noise spatial eigenmatrix by eigenvalue factorization of the correlation matrix, one of a row and a column of the noise spatial eigenmatrix being an eigenvector belonging to a noise eigen-space;

a triangular matrix calculation unit for factorizing a matrix including a product of the noise spatial eigenmatrix and a conjugated and transposed matrix

of the noise spatial eigenmatrix to a product of one of an upper triangular matrix and a lower triangular matrix; and

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix.

94. A directivity variable transceiver according to claim 93, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the noise spatial eigenmatrix calculation unit applies the eigenvalue factorization to the unitary-transformed correlation matrix.

95. A directivity variable transceiver according to claim 91,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the

antenna elements;

an inverse matrix calculation unit for calculating an inverse matrix of the correlation matrix;

a triangular matrix calculation unit for factorizing the inverse matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

96. A directivity variable transceiver according to claim 95, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the inverse matrix calculation unit calculates an inverse matrix of the unitary-transformed correlation matrix.

97. A directivity variable transceiver according to claim 91,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the

converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an inverse matrix calculation unit for calculating an inverse matrix of the one of the upper triangular matrix and the lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the inverse matrix of the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

98. A directivity variable transceiver according to claim 97, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the triangular matrix calculation unit factorizes the unitary-transformed correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix

99. A directivity variable transceiver according to claim 91,

wherein said radio-wave arrival-direction estimating apparatus comprises:

an array antenna including a plurality of antenna elements;

a receiving unit for converting frequency of a RF signal received by each of the antenna elements in the array antenna, demodulating the converted signal, and outputting the demodulated signal;

an A/D converter for converting the demodulated signal to a complex digital signal;

a correlation matrix calculation unit for calculating a correlation matrix by correlation calculation of the complex digital signal between the antenna elements;

a triangular matrix calculation unit for factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

an arrival-angle evaluation unit for calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

an arrival-angle determination unit for determining an arrival angle based on the evaluation value by the arrival-angle evaluation unit.

100. A directivity variable transceiver according to claim 99, wherein

the plurality of antenna elements are arranged linearly at a constant interval,

said radio-wave arrival-direction estimating apparatus further

comprises a unitary transforming unit for unitary-transforming the correlation matrix, and

the triangular matrix calculation unit factorizes the unitary-transformed correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix

101. A radio-wave arrival-direction estimating method comprising:

(a) calculating a correlation matrix of signals received by an array antenna including a plurality of the antenna elements by correlation calculation between the antenna elements;

(b) calculating a noise spatial eigenmatrix by eigenvalue factorization of the correlation matrix, one of a row and a column of the noise spatial eigenmatrix being an eigenvector belonging to a noise eigen-space;

(c) factorizing a matrix including a product of the noise spatial eigenmatrix and a conjugated and transposed matrix of the noise spatial eigenmatrix to a product of one of an upper triangular matrix and a lower triangular matrix;

(d) calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

(e) determining an arrival angle based on the evaluation value every predetermined angle.

102. A radio-wave arrival-direction estimating method according to claim 101 further comprising a step of unitary-transforming the correlation matrix between step (a) and step (b), when the plurality of antenna elements are

arranged linearly at a constant interval.

103. A radio-wave arrival-direction estimating method comprising:

(a) calculating a correlation matrix of signals received by an array antenna including a plurality of the antenna elements by correlation calculation between the antenna elements;

(b) calculating an inverse matrix of the correlation matrix;

(c) factorizing the inverse matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

(d) calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

(e) determining an arrival angle based on the evaluation value every predetermined angle.

104. A radio-wave arrival-direction estimating method according to claim 103 further comprising a step of unitary-transforming the correlation matrix between step (a) and step (b), when the plurality of antenna elements are arranged linearly at a constant interval.

105. A radio-wave arrival-direction estimating method comprising:

(a) calculating a correlation matrix of signals received by an array antenna including a plurality of the antenna elements by correlation calculation between the antenna elements;

(b) factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

(c) calculating an inverse matrix of the one of the upper triangular matrix and the lower triangular matrix;

(d) calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the inverse matrix of the one of the upper triangular matrix and the lower triangular matrix; and

(e) determining an arrival angle based on the evaluation value every predetermined angle.

106. A radio-wave arrival-direction estimating method according to claim 105 further comprising a step of unitary-transforming the correlation matrix between step (a) and step (b), when the plurality of antenna elements are arranged linearly at a constant interval.

107. A radio-wave arrival-direction estimating method comprising:

(a) calculating a correlation matrix of signals received by an array antenna including a plurality of the antenna elements by correlation calculation between the antenna elements;

(b) factorizing the correlation matrix to a product of one of an upper triangular matrix and a lower triangular matrix;

(c) calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the one of the upper triangular matrix and the lower triangular matrix; and

(e) determining an arrival angle based on the evaluation value every predetermined angle.

108. A radio-wave arrival-direction estimating method according to claim 107 further comprising a step of unitary-transforming the correlation matrix between step (a) and step (b), when the plurality of antenna elements are arranged linearly at a constant interval.

109. A radio-wave arrival-direction estimating method comprising:

(a) calculating a correlation vector of signals received by an array antenna including a plurality of the antenna elements by correlation calculation between a reference antenna element and another antenna element;

(b) calculating an evaluation value of an arrival-angle evaluation function every predetermined angle, the arrival-angle evaluation function being expressed using the correlation vector; and

(c) determining an arrival angle based on the evaluation value every predetermined angle.

110. A radio-wave arrival-direction estimating method according to claim 109 further comprising a step of unitary-transforming the correlation matrix between step (a) and step (b), when the plurality of antenna elements are arranged linearly at a constant interval.